

National Aeronautics and Space Administration



Modeling Efforts with the OpenMDAO Framework

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Subsonic Fixed Wing Project
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www.nasa.gov

OpenMDAO Background



OpenMDAO.org

- Open source Multidisciplinary Design Analysis and Optimization (MDAO) Framework
- Built using the Python programming language
- Distributed under the Apache V2.0 open source license
- A research effort established with the goal of providing a common platform for MDAO that will help foster collaboration between industry, academia, and government
- Website: <http://openmdao.org>
- Source Code Repository:
<http://github.com/openmdao/openmdao-framework>

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Motivation



- Provide a common platform to expand the state of the art for MDAO through collaboration between industry, academia, and government
- Develop an MDAO framework that can support advanced MDAO algorithms to enable high-fidelity optimizations at all parts of the design process
- Encourage greater code re-use and software sharing in the MDAO field through the use of open source software development and distribution methods.

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Open Source Software Community



- Released under the Apache V2.0 License
 - Extremely Permissive license which allows you to do almost anything
 - <http://www.apache.org/licenses/LICENSE-2.0.html>
 - Proprietary code can interface with OpenMDAO, without needing to be open source itself
 - Apache is compatible with the majority of other open source licenses out there
- Using Github as the portal for all community code contributions
 - Other software hosted on github.com: EGADS, GEM, GeoMACH, OpenMDAO official plugins
- Community forums:
<http://openmdao.org/forum>
 - Active and growing user groups
 - Questions and answer style which encourages discussion



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New Features in the Framework



- OpenMDAO v 0.2.3 released, April 2012
- New Optimizers: SLSQP, COBYLA, PyOpt, IPOpt
- Support for components with analytic derivatives
- Automatic implementations of MDAO Architectures:
 - IDF, MDF, CO, BLISS, BLISS-2000
- Greater support for High Performance Computing
- Easy installation of OpenMDAO plugins from the github plugins repository: <http://github.com/openmdao-plugins>
- Support for Python 2.7

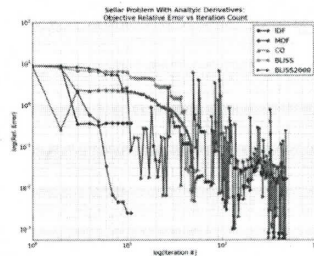
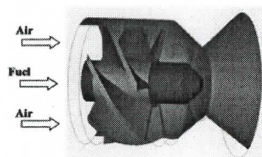
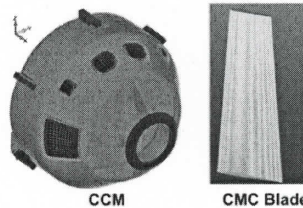
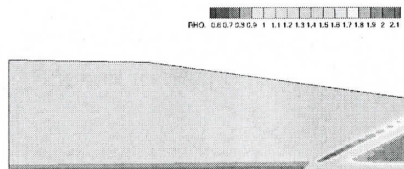
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Modeling Efforts with OpenMDAO



- Working with researchers from Subsonic Fixed Wing and Supersonics to enable new research with MDAO methods



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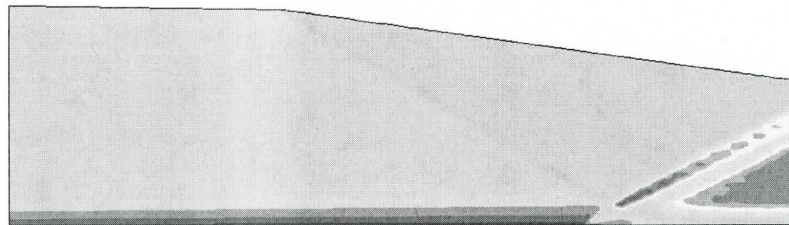
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Modeling Efforts: Supersonic Inlet



- Supersonic Inlet Geometry Optimization with Overflow
 - Wrapper for Overflow V2.2 available on <http://github.com/opemdao-plugins>
- Model built to investigate the optimal location and size for bleed holes in the inlet flow path
- Execution run remotely via High Performance Compute Cluster

RHO: 0.6 0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2 2.1



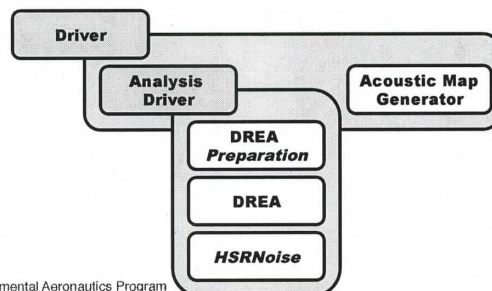
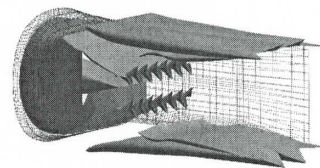
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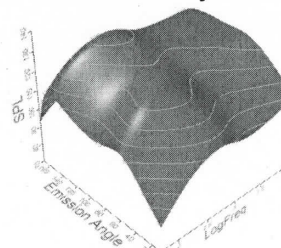
Modeling Efforts: Mixer-Ejector Nozzle



- Goal: develop a multidisciplinary analysis providing performance and acoustic maps for system level analysis
- Low fidelity analysis tools
 - Mixer-ejector performance: DREA
 - Mixer-ejector acoustics: HSRNoise
- Multidisciplinary analysis capability has been demonstrated for a notional design



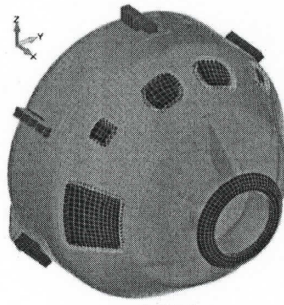
SPL Values for the Flyover Observer



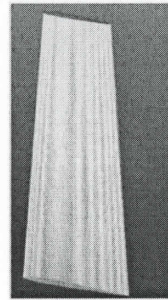
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Modeling Efforts: Structural Optimization



CCM



CMC Blade

- Wide Range of Different Finite Element Models: Composite Crew Module, 25 Bar Truss, Turbine Blades
- Deterministic and stochastic structural optimizations
- Experimenting with optimization strategies using multiple optimizers
- Working with multi-objective optimizations

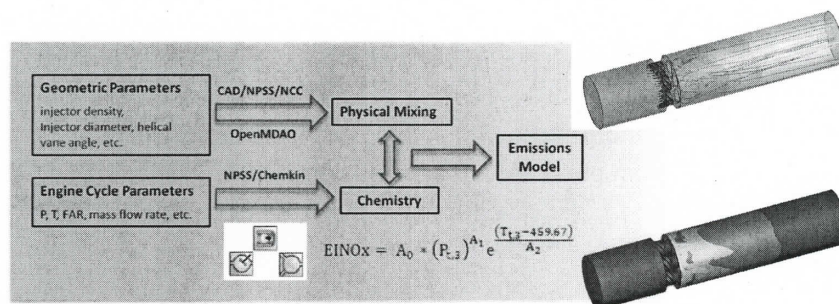
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Modeling Efforts: Lean Direct Injection



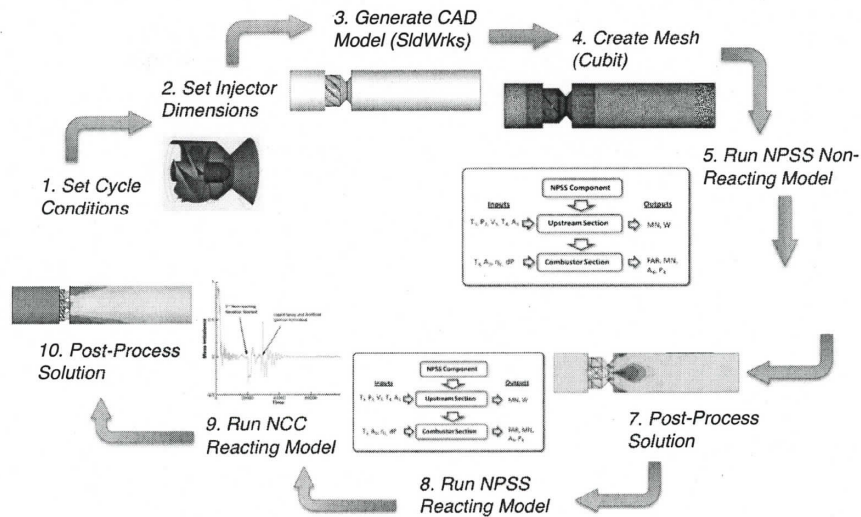
- Multi-fidelity modeling effort, using NPSS and NCC
- Tight integration with Solidworks parametric geometry
- Design space includes major topological changes to geometry



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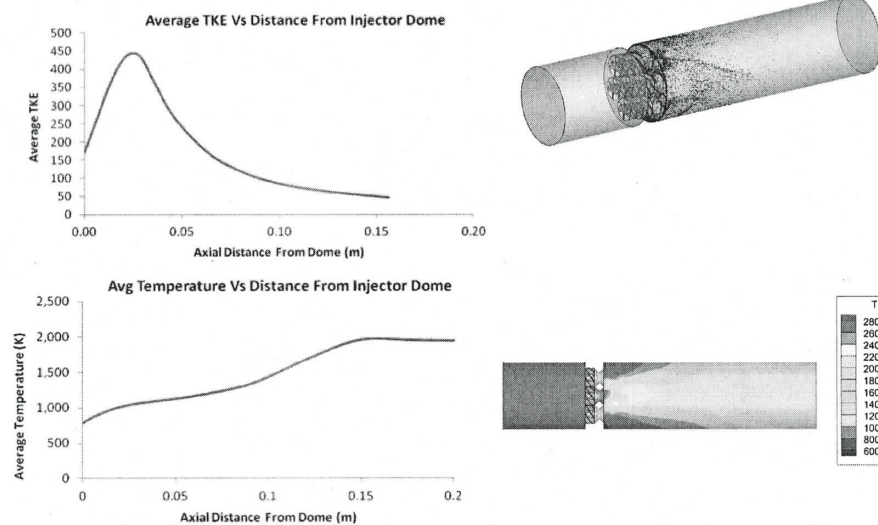
Modeling Efforts: LDI cont.



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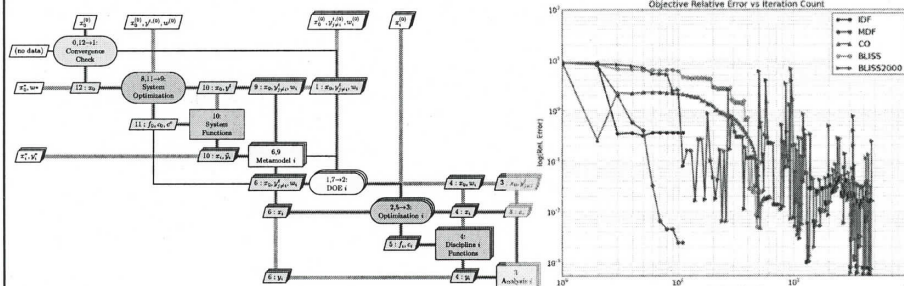
Modeling Efforts: LDI cont.



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Modeling Efforts: MDAO Benchmarking



- Using OpenMDAO for standardized MDAO architecture testing
- Implemented IDF, MDF, CO, BLISS, BLISS-2000
- Automatically apply MDAO architectures to any problem
- Building a suite of test problems to test architectures against
- Working with AIAA MDO Technical Committee to expand test suite.

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Integrating Geometry Capabilities



- Developing a tight integration with multiple geometry tools via a common interface
- NRA Effort: University of Michigan, MIT:
 - GeoMACH: open source conceptual geometry engine suitable for optimization with high fidelity analysis tools
- NRA Effort: MIT, Syracuse University:
 - EGADS: Utility for interfacing with OpenCASCADE kernel
 - OpenCSM: open source CAD based approach to geometry for MDAO
 - Geometry Engine for MDAO (GEM): universal interface for working with geometry tools

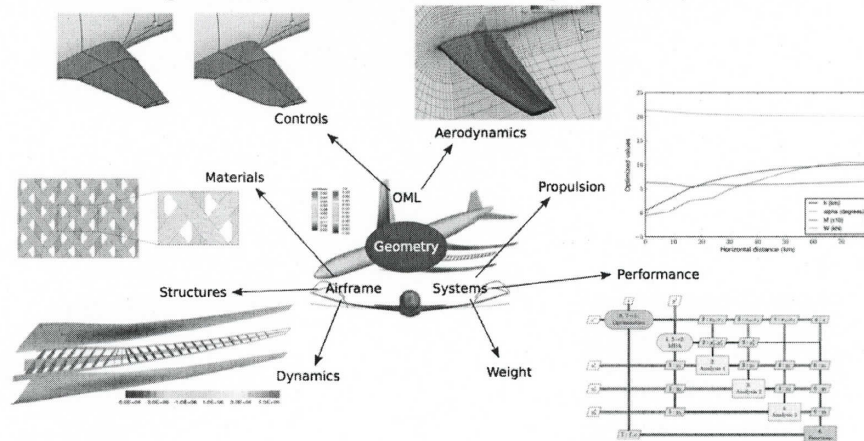
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GeoMACH



- PI: Dr. Martins, University of Michigan
- Fast b-spline based geometry generation with analytic derivatives
- Produces geometry suitable for use with high fidelity optimizations



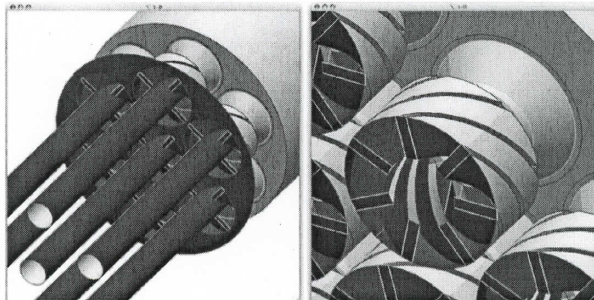
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OpenCSM and EGADS



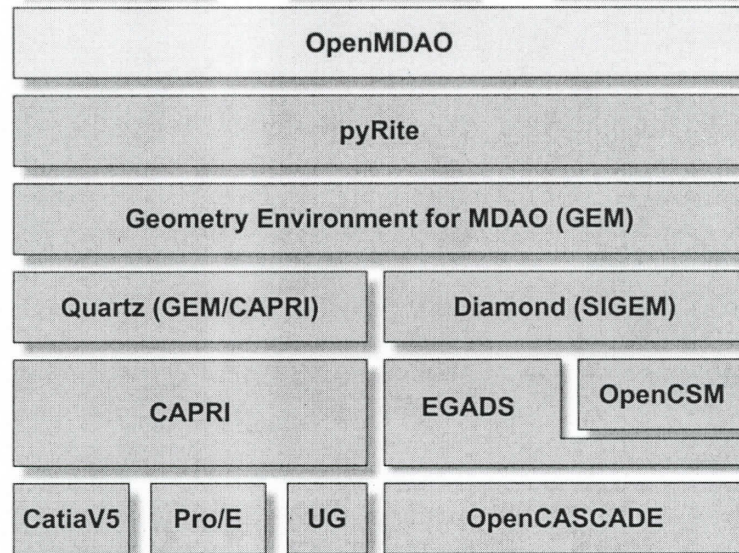
- PI: Robert Haimes, MIT; CO-PI: Dr. Dannenhoffer, Syracuse University
- CAD based approach to geometry generation
- Support for Analytic Derivatives
- EGADS provides services to access the OpenCASCADE Kernel
 - OpenCSM uses EGADS to talk to OpenCASCADE geometry Kernel
 - OpenVSP project is using EGADS for STEP file output capability
 - GeoMach links with EGADS to provide an efficient link to the GEM API



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Geometry Environment for MDAO (GEM)



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